SECTION 7

MINIMUM REQUIREMENT #6

RUNOFF TREATMENT

PROJECT RUNOFF TREATMENT DESIGN OVERVIEW

South Basin:
The south basin will utilize 1' of dead storage for sediment control, and a biofiltration swale designed to treat flows after detention. See calculations below from wwhm3 for water quality flow rates and for the design of the biofiltration swale as both a treatment component, and analyzed for stability in larger flows.

North Basin:

The North storm drainage basin will utilize the proposed roadside ditch in the easement connection road as a biofiltration swale to treat the undetained flows from the north basin. These flows will also be presented from wwhm3 for water quality flow rates and for the design of the biofiltration swale as both a treatment component, and analyzed for stability in larger flows

APPENDIX 7-A

WATER QUALITY
DESIGN CALCULATIONS

South Basin Biofiltration Swale Design:

From WWHM3 analysis. The Treatment flow rate is the full two year q when swale is downstream of detention, thus shown on the mitigated 2 year, the water quality section is shown below for redundancy.

```
Water Quality BMP Flow and Volume for POC  1.
On-line facility volume:  1.0322 acre-feet
On-line facility target flow:  0.01 cfs.
Adjusted for 15 min:  0.5502  cfs.
Off-line facility target flow:  0.3492 cfs.
Adjusted for 15 min:  0.3683 cfs.
```

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	1.14887
5 year	1.723939
10 year	2.179317
25 year	2.847225
50 year	3.416976
100 year	4.052958

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)	
2 year	0.661346	←------Treatment Flow Rate (after detention,full 2 yr.)
5 year	0.960067	
10 year	1.200398	
25 year	1.557991	
50 year	1.867299	
100 year	2.216741	←------------ Stability Flow Rate

Eaglemont (South Basin)
Biofiltration Swale Design Calculations
(Per Appendix AII-6.1, 2005 DOE Manual)

Design Steps:

Step D-1: Establish the design flow depth

Design Flow Depth (y) = 4 in. <--- (Note: The swale is not to be frequently mowed, and should retain a length of 6" or more. Step D-1 calls for the design flow depth to be 2" below the winter vegetation height. Assume 4")

Step D-2: Select the appropriate Manning's coefficient

Manning's Coefficient (n) = 0.07 <--- (from Table II-2.8, Chapter II-2)

Step D-3: Select Channel Geometry

Swale Shape = Trapezoidal

Side Slopes = 3 :1

Channel Slope = 2 %

Step D-4: Calculate the bottom width required to treat the 6-mo/24-hr storm event

6-mo/24-hr Design Flowrate = 0.66 cfs <--- (2-yr release rate from the detention facility used in lieu of 6-mo. Event)

Bottom Width = 5.00 ft

Calculated Flowrate = 2.59 cfs <--- (this is the treatment capacity of the swale, and must be larger than the 6-mo/24-hr design flowrate)

Shape	y	A	P	R
Rectangular	0.3333	1.6667	5.6667	0.2941
Trapezoidal	0.3333	2.0000	7.1082	0.2814
Triangular	0.3333	0.3333	2.1082	0.1581

Step D-5: Compute the cross sectional flow area at the calculated flowrate

A = 2.00 ft²

Step D-6: Compute the flow velocity at the Design Flowrate

V = 0.33 ft/s <--- (this velocity must be less than 1.5 ft/s to allow particle sedimentation)

Step D-7 Through Step D-15 The 1992 DOE Manual provides an approximate calculation method for the bottom width in Step D-4, to assist in hand-calculation. Steps D-7 through D-15 are intended to refine that calculation. A more accurate, iterative method was used in the calculations above, and therefore, Steps D-7 through D-15 are not necessary.

Stability Check Steps:

Step SC-1: Calculate the 100-yr/24-hr design storm flowrate

100-yr/24-hr Design Flowrate = 2.22 cfs <--- (see appendix 3-A)

Note: Steps SC-2, SC-3, and SC-6 through SC-9 contain an approximate method for hand-calculating the conveyance velocity during the 100-yr/24-hr event. This analysis will provide a more accurate, computer calculation, and will skip the above-listed steps:

Step SC-4: Establish the maximum permissible velocity for erosion prevention from the following table.

Cover	Slope %	Max. Settling Velocity (ft/s)
Kentucky Bluegrass Tall Fescue	0-5	5
Kentucky Bluegrass Tall Fescue Western Wheatgrass	5-10	4
Grass-legume Mixture	0-5 5-10	4 3
Red Fescue Redtop	0-5 5-10	2.5 Not Recommended

Selected Maximum Velocity = 4 ft/s

Step SC-5: Select a Manning's 'n' for conveyance flows

Manning's Coefficient (n) = 0.04

Step SC-10: Compute the actual flow velocity for the 100-yr/24-hr storm event

Conveyance Flow Depth (y) = 0.23 ft <--- (solved iteratively)

Channel Shape = Trapezoidal <--- (from previous page)

Bottom Width (b) = 5.00 ft <--- (from previous page)

Side Slopes (z) = 3 :1 <--- (from previous page)

Channel Slope (S) = 2.00 % <--- (from previous page)

Cross-sectional flow area (A) = 1.26 ft² <--- (calculated from channel geometry)

Calculated flow rate (Q_{CALC}) = 2.22 cfs <--- (this is the flow rate calculated from the conveyance flow depth above, and is provided for comparison with the 100-yr/24-hr Design Flow rate

100-yr/24-hr Design Flowrate = 2.22 cfs <--- (from above)

100-yr/24-hr Design Velocity = 1.77 fps <--- (must be less than the maximum specified in step SC-4)

<--- Use the solver to determine the flow depth
Target Cell is M105
Set target to Value of 0
By Changing Cell F95

Shape	A	P	R	Q
Rectangular	1.1500	5.4600	0.2106	2.1446
Trapezoidal	1.2558	6.4546	0.1946	2.2212
Triangular	0.1587	1.4546	0.1091	0.1909

$Q_{CALC} - Q_{100}$ = 0.00 **<--- Used in Solving for the Conveyance Flow Depth**

Final Bioswale Sizing:

Based on the previous calculations, the bioswale will require the following dimensions:

Channel Shape = Trapezoidal <-- (from page 1)

Channel Slope = 2 % <-- (from page 1)

Channel Side Slopes = 3 :1 <-- (from page 1)

100-yr/24-hr conveyance flow depth = 0.23 ft. <-- (from page 2)

Required Freeboard = 1.00 ft.

Design Swale Depth = 2.00 ft. <-- (conveyance depth + freeboard rounded up to nearest 1/2 ft.)

The 1992 DOE Manual calls for a minimum swale length of 200 ft, however, the manual allows the reduction of this length if the swale is widened to provide the same cross-sectional volume. The following calculation will determine the design width & length of the bioswale.

Required cross-sectional area (treatment) = 2.00 ft^2 <-- (from page 1)

Required treatment volume = 400.00 ft^3 <-- (treatment area * 200')

Desired Swale Length = 165 ft

Required cross-sectional treatment area = 2.42 ft^2 <-- (treatment volume / desired length)

Adjusted Bottom Width = 5 ft <-- (calculated from channel geometry maintaining the previous treatment depth)

Shape	b
Rectangular	7.2727
Trapezoidal	6.2727
Triangular	0.0000

Design Bottom Width = 5 ft <-- (adjusted bottom width, rounded up to nearest 1/2 ft)

Calculated cross-sectional treatment area = 2.00 ft^2

Shape	A	P	R	Q
Rectangular	1.6667	5.6667	0.2941	3.8830
Trapezoidal	2.0000	7.1082	0.2814	16.0786
Triangular	0.3333	2.1082	0.1581	3.2474

North Basin Biofiltration Swale Design:

The North storm drainage basin will utilize the proposed roadside ditch in the easement connection road as a biofiltration swale to treat the undetained flows from the north basin. These flows will also be presented from wwhm3 for water quality flow rates and for the design of the biofiltration swale as both a treatment component, and analyzed for stability in larger flows.

From the water quality flow page of the WWHM3 printout:

```
Water Quality BMP Flow and Volume for POC  1.
On-line facility volume:  0.1435 acre-feet
On-line facility target flow:  0.01 cfs.  ←--------------------  Treatment flow rate
Adjusted for 15 min:  0.0762  cfs.
Off-line facility target flow:  0.0473 cfs.
Adjusted for 15 min:  0.0496 cfs.
```

For Stability Calculations for bioswale
MITIGATED LAND USE

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.217557
5 year	0.325868
10 year	0.411517
25 year	0.537
50 year	0.643936
100 year	0.763209

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)	
2 year	0.295045	
5 year	0.41956	
10 year	0.510242	
25 year	0.634313	
50 year	0.733733	
100 year	0.83924	←------------------Stability Flow Rate

Biofiltration Swale Calculations: (Roadside Ditch w/Checkdamns)

Eaglemont (North Basin)
Biofiltration Swale Design Calculations
(Per Appendix AIII-6.1, 2005 DOE Manual)

Design Steps:

Step D-1: **Establish the design flow depth**

Design Flow Depth (y) = 4 in.

<--- (Note: The swale is not to be frequently mowed, and should retain a length of 6" or more. Step D-1 calls for the design flow depth to be 2" below the winter vegetation height. Assume 4")

Step D-2: **Select the appropriate Manning's coefficient**

Manning's Coefficient (n) = 0.07 <--- (from Table III-2.8, Chapter III-2)

Step D-3: **Select Channel Geometry**

Swale Shape = Trapezoidal

Side Slopes = 3 :1

Channel Slope = 5 %

Step D-4: **Calculate the bottom width required to treat the 6-mo/24-hr storm event**

6-mo/24-hr Design Flowrate = 0.07 cfs <--- (2-yr release rate from the detention facility used in lieu of 6-mo. Event)

Bottom Width = 2.00 ft

Calculated Flowrate = 1.86 cfs <--- (this is the treatment capacity of the swale, and must be larger than the 6-mo/24-hr design flowrate)

Shape	y	A	P	R
Rectangular	0.3333	0.6667	2.6667	0.2500
Trapezoidal	0.3333	1.0000	4.1082	0.2434
Triangular	0.3333	0.3333	2.1082	0.1581

Step D-5: **Compute the cross sectional flow area at the calculated flowrate**

A = 1.00 ft^2

Step D-6: **Compute the flow velocity at the Design Flowrate**

V = 0.07 ft/s <-- (this velocity must be less than 1.5 ft/s to allow particle sedimentation)

Step D-7 Through Step D-16 The 1992 DOE Manual provides an approximate calculation method for the bottom width in Step D-4, to assist in hand-calculation. Steps D-7 through D-15 are intended to refine that calculation. A more accurate, iterative method was used in the calculations above, and therefore, Steps D-7 through D-15 are not necessary.

Stability Check Steps:

Step SC-1: **Calculate the 100-yr/24-hr design storm flowrate**

100-yr/24-hr Design Flowrate = 0.84 cfs <--- (see appendix 3-A)

Note: Steps SC-2, SC-3, and SC-6 through SC-9 contain an approximate method for hand-calculating the conveyance velocity during the 100-yr/24-hr event. This analysis will provide a more accurate, computer calculation, and will skip the above-listed steps:

Step SC-4: **Establish the maximum permissible velocity for erosion prevention from the following table.**

Cover	Slope %	Max. Settling Velocity (ft/s)
Kentucky Bluegrass Tall Fescue	0-5	5
Kentucky Bluegrass Tall Fescue Western Wheatgrass	5-10	4
Grass-legume Mixture	0-5 5-10	4 3
Red Fescue Redtop	0-5 5-10	2.5 Not Recommended

Selected Maximum Velocity = 4 ft/s

Step SC-5: **Select a Manning's 'n' for conveyance flows**

Manning's Coefficient (n) = 0.04

Step SC-10: **Compute the actual flow velocity for the 100-yr/24-hr storm event**

Conveyance Flow Depth (y) = 0.18 ft <-- (solved iteratively)

Channel Shape = Trapezoidal <-- (from previous page)

Bottom Width (b) = 2.00 ft <-- (from previous page)

Side Slopes (z) = 3 :1 <-- (from previous page)

Channel Slope (S) = 5.00 % <-- (from previous page)

Cross-sectional flow area (A) = 0.41 ft^2 <-- (calculated from channel geometry)

Calculated flow rate (Q_{CALC}) = 0.89 cfs <-- (this is the flowrate calculated from the conveyance flow depth above, and is provided for comparison with the 100-yr/24-hr Design Flowrate

100-yr/24-hr Design Flowrate = 0.84 cfs <-- (from above)

100-yr/24-hr Design Velocity = 2.04 fps <-- (must be less than the maximum specified in step SC-4)

<-- Use the solver to determine the flow depth
Target Cell is M105
Set target to Value of 0
By Changing Cell F95

Shape	A	P	R	Q
Rectangular	0.3500	2.3500	0.1489	0.8191
Trapezoidal	0.4113	3.1068	0.1324	0.8897
Triangular	0.0919	1.1068	0.0830	0.1456

$Q_{CALC} - Q_{100}$ = 0.05 **<-- Used in Solving for the Conveyance Flow Depth**

Final Bioswale Sizing:

Based on the previous calculations, the bioswale will require the following dimensions:

Channel Shape =	Trapezoidal		<-- (from page 1)
Channel Slope =	5	%	<-- (from page 1)
Channel Side Slopes =	3	:1	<-- (from page 1)
100-yr/24-hr conveyance flow depth =	0.18	ft.	<-- (from page 2)
Required Freeboard =	1.00	ft.	
Design Swale Depth =	2.00	ft.	<-- (conveyance depth + freeboard rounded up to nearest 1/2 ft.)

The 1992 DOE Manual calls for a minimum swale length of 200 ft, however, the manual allows the reduction of this length if the swale is widened to provide the same cross-sectional volume. The following calculation will determine the design width & length of the bioswale.

Required cross-sectional area (treatment) =	1.00	ft^2	<-- (from page 1)
Required treatment volume =	200.00	ft^3	<-- (treatment area * 200')
Desired Swale Length =	165	ft	
Required cross-sectional treatment area =	1.21	ft^2	<-- (treatment volume / desired length)
Adjusted Bottom Width =	5	ft	<-- (calculated from channel geometry maintaining the previous treatment depth)
Design Bottom Width =	5	ft	<-- (adjusted bottom width, rounded up to nearest 1/2 ft)
Calculated cross-sectional treatment area =	2.00	ft^2	

Shape	b
Rectangular	3.6364
Trapezoidal	2.6364
Triangular	0.0000

Shape	A	P	R	Q
Rectangular	1.6667	5.6667	0.2941	6.1396
Trapezoidal	2.0000	7.1082	0.2814	25.4225
Triangular	0.3333	2.1082	0.1581	5.1345

Performance Standards For Water Quality Treatment:

Treatment Facility Sizing:

Water Quality Design Storm Volume: The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6- month, 24-hour storm). Wetpool facilities are sized based upon the volume of runoff predicted through use of the Natural Resource Conservation Service curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm. Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model may be used.

Water Quality Design Flow Rate:

- Preceding Detention Facilities or when Detention Facilities are not required: The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated. Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80% TSS removal).

- Downstream of Detention Facilities: The full 2-year release rate from the detention facility.

Alternative methods can be used if they identify volumes and flow rates that are at least equivalent.